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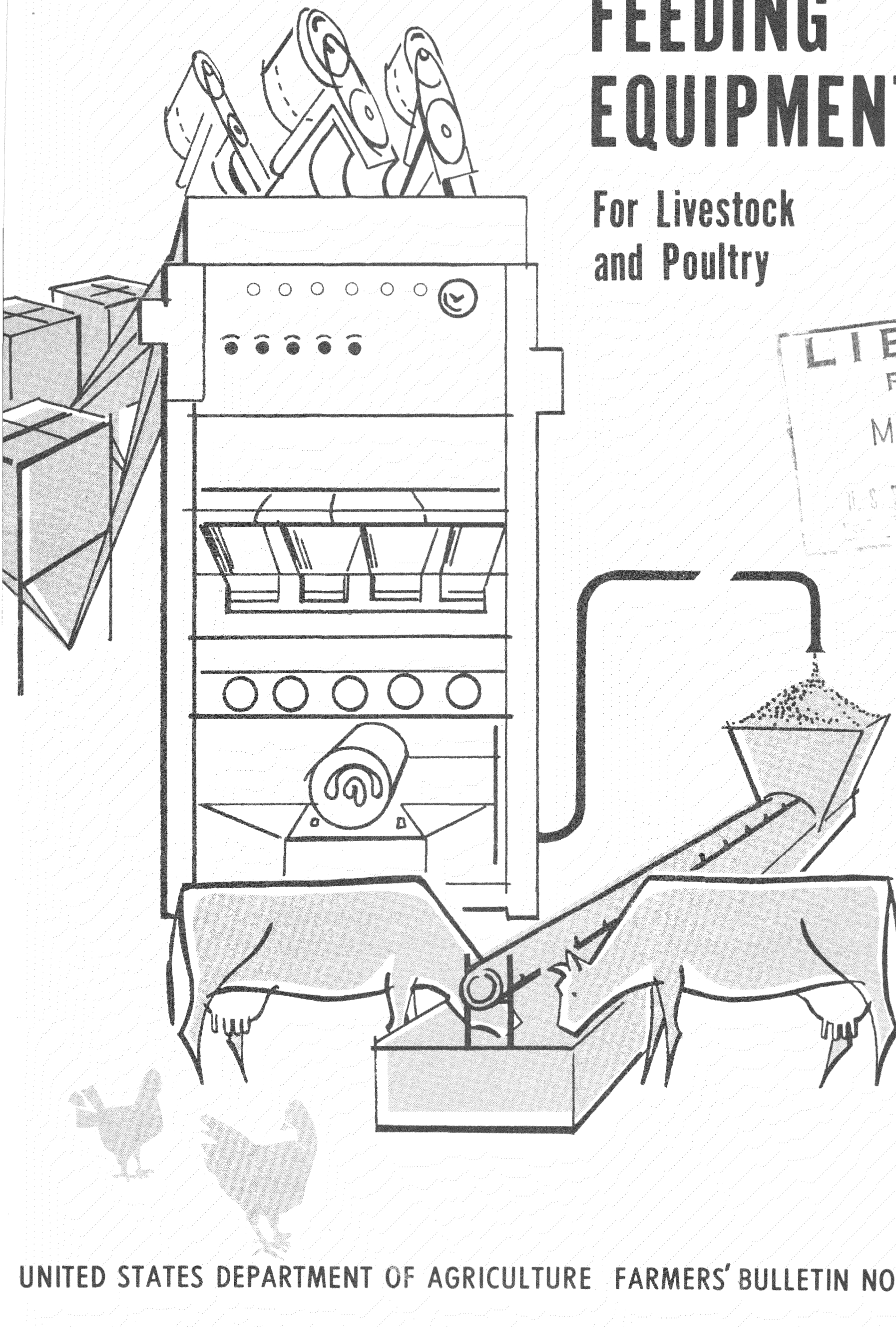
AUTOMATIC FEEDING EQUIPMENT

For Livestock and Poultry



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CONTENTS

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AUTOMATIC FEEDING EQUIPMENT

FOR LIVESTOCK AND POULTRY

By H. B. PUCKETT, *agricultural engineer, Agricultural Engineering Research Division, Agricultural Research Service*[1]

Handling and processing feed for livestock or poultry is laborious and time-consuming work on many farms.

Mechanization and automation of the feeding operation can—

- Reduce the amount of labor required and thus reduce labor costs and free labor for other farm work.

- Permit expansion of livestock or poultry production—that is, an increase in the number of animals that can be handled.

With the electrical equipment and controls available, it is possible to remove feed from storage, mix and grind it to the desired ration, and deliver it to the livestock or poultry with little or no manual labor.

An automatic feeding system may be set up by adding to and modifying existing facilities and equipment or by designing a completely new layout of buildings and equipment. Whichever procedure is followed, careful planning is essential to insure an efficient and economical system.

EQUIPMENT FOR A FEEDING SYSTEM

A feed-processing system can vary from simply a storage bin and mill to a complex grouping of completely automated equipment. A complete automatic feeding system would include—

Storage bins for the various feed ingredients, such as corn, grain, and supplement.

Blender—two or more feed meters—to blend or mix the ingredients in the correct proportion.

Mill or grinder to grind and further mix the ingredients. In some cases, blender and grinder may be combined as a single unit (fig. 1).

Conveyors to move the in-

[1] This publication is based on results of cooperative research between the Agricultural Engineering Research Division, Agricultural Research Service, and the Illinois Agricultural Experiment Station. The drawings of feeding systems (figs. 19 through 24) are by courtesy of the Illinois Agricultural Experiment Station.

BN–18095

Figure 1.—Automatically controlled augers bring feed ingredients from supply bins to this automatic mill. Here the ingredients are blended and ground and then delivered to a conveyor (an auger in this case).

gredients from storage to processing (mixing and grinding), and the ground feed from processing to the feeding points. Augers and pneumatic conveying systems are examples of conveyors.

Distributors to receive the feed from the conveyors and distribute it before the animals. An auger mounted above a feed bunk (commonly referred to as a bunk feeder) and a self-feeder are examples of distributors.

Automatic controls to regulate and synchronize the operation of the various equipment components in the system.

STORAGE BINS

The various feed ingredients can be stored in hopper-bottom or flat-bottom bins.

Hopper-bottom bins unload by gravity, which is an economical method of moving feed in an automatic feeding system. However, hopper-bottom storage usually costs more per cubic foot than flat-bottom storage. Also, oil meals and fibrous feeds tend to cake in storage and bridge during discharge. This can impede unloading by gravity from hopper-bottom bins. The problem can be minimized by using pelleted feed ingredients.

Flat-bottom bins can be unloaded by mechanical unloaders. However, most such equipment does not completely unload a bin; the last several feet of feed must be unloaded manually.

One mechanical unloader that almost completely unloads a round or square flat-bottom bin is available. It consists basically of two separately powered augers. One auger sweeps around the storage bin, gathers the feed material, and conveys it to a small hopper in the center of the bin. The other auger, which operates below the bin floor, removes the feed material from the hopper, conveys it to the outside edge of the bin, and deposits it in another conveyor.

This unloader is designed primarily to unload feed automatically at the relatively low rate desirable for automatic feeding systems. High-powered models are available for unloading or moving feed at a high rate.

BLENDER (FEED METERS)

Livestock or poultry feed can be mixed before or after it is ground. The mixing of the ingredients before they are ground is discussed here.

In an automatic feeding system, the feed ingredients are removed from storage, mixed or blended, and then ground and fed.

A satisfactory mixing and grinding operation requires (1) meters that will blend the different feed ingredients in the correct proportion and (2) a mill that will grind different size feed ingredients simultaneously.

Different types of volumetric meters have been tested in automatic feeding systems. Those found to be the most satisfactory are the belt, auger, fluted wheel, and vibrator.

Belt Meter

This meter (fig. 2) is designed to meter non-free-flowing materials or materials that tend to compact in storage and bridge during discharge. It consists of a metal mat or rubber belt, 14 to 36 inches wide and several feet long, which is installed as the floor of the storage bin, and a strike-off gate to regulate the amount of material pulled from

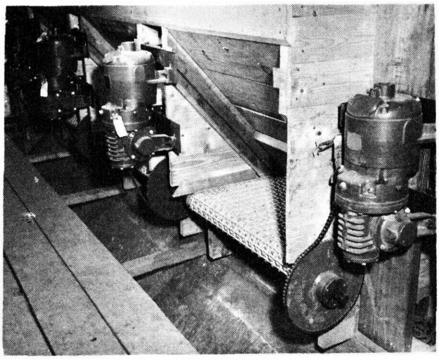

Figure 2.—A metal belt meter consists of a powered belt which serves as the bin floor and a strike-off gate which regulates the amount of material pulled from the bin.

the bin. It is a reasonably accurate meter, but its output will vary with operating conditions (aggregate size and trash and moisture content). It is the most expensive meter, because of the expensive drive unit required.

Auger Meter

An auger meter is accurate when operated at low speeds and accurate enough for most feed mixing when operated at relatively high speeds (800 to 1,000 r.p.m.). It works best when one to two convolutions of the auger flighting are exposed to the feed material and the output rate is controlled by regulating auger speed. The auger is best utilized in a blender driven by a single power source. Small automatic feed mills with integrally mounted auger-type blending units are available (fig. 3).

Fluted-Wheel Meter

A fluted-wheel meter is accurate enough for metering free-flowing small grain and supplement. It is best used in a blending unit driven by a single power source. A small grain seeder that uses a fluted wheel to control the seeding rate can be used as a meter (fig. 4).

Vibrator Meter

This is a very useful meter for an automatic feeding system. It is low in cost, simple in construction and operation, versatile, and accurate. It can be located at any point in a feeding system to meter free-flowing feed material.

The meter (fig. 5) consists of a metal box with a trough on one side, an adjustable gate, and an electric vibrator attached to the bottom of the trough. No motor

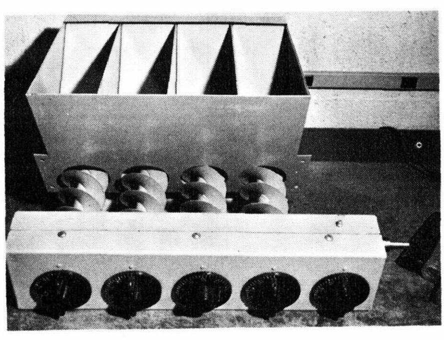

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Figure 3.—The blending unit of a small, automatic feed-grinding mill. The dials regulate the average speed of, and relative speed between, the four augers.

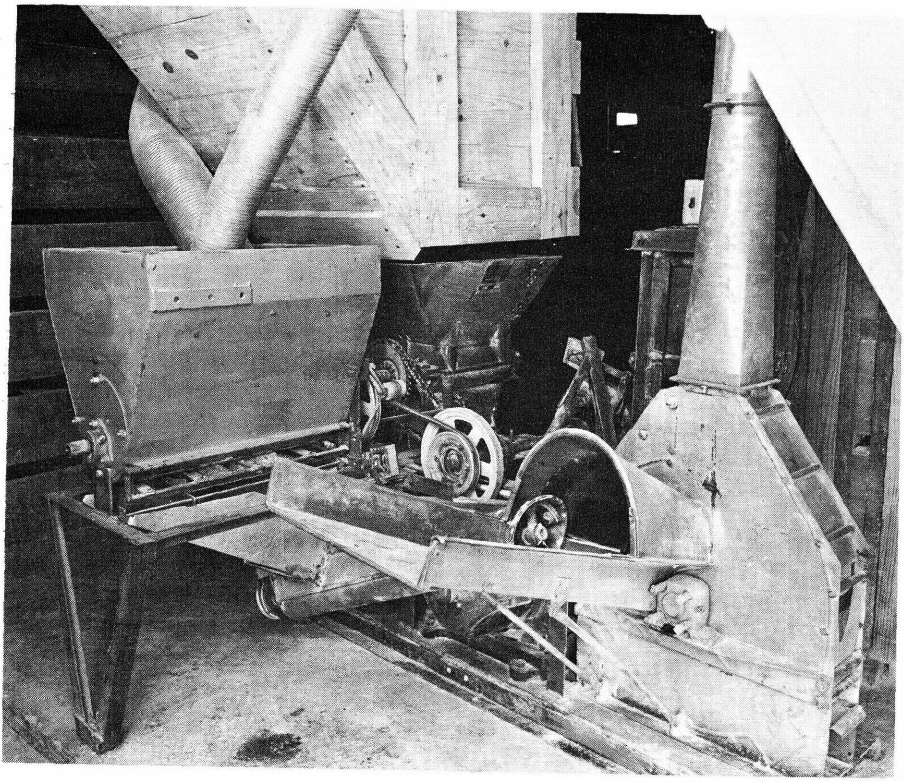

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Figure 4.—Small grain seeders that use a fluted wheel to control the seeding rate can satisfactorily meter small grains in an automatic feeding system. (Courtesy of Department of Agricultural Engineering, Kansas State University.)

is required to operate the meter; it operates on alternating-current (a.c.) electric power.

Output of the meter may be controlled by adjusting the gate opening or by adjusting the current in the vibrator coil. The current in the vibrator coil can be adjusted with a series rheostat.

The meter is not easily plugged by trashy or lumpy material. However, such material will affect the output rate while passing through the meter.

The meter is very adaptable for other jobs requiring uniform delivery of granular materials. For example, it can be used to meter supplement on to silage as the silage is conveyed to a feed bunk (fig. 6). Or it can be used to mix other feed ingredients with silage as the silage is loaded into a silo.

Figure 7 shows construction details of the vibrator meter. The bottom of the meter should be of lighter-gage metal than the sides so that the bottom will vibrate more readily than the sides.

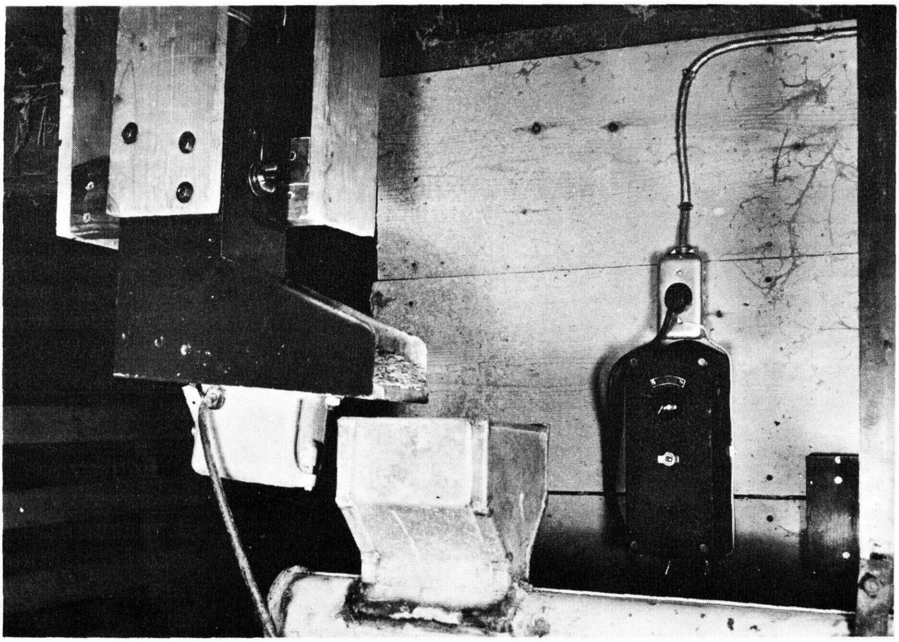

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Figure 5.—A vibrator meter can be used to meter free-flowing granular materials in an automatic feeding system.

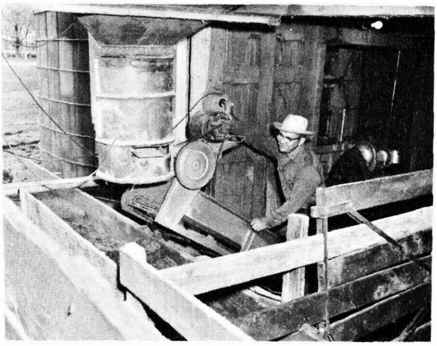

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Figure 6.—A vibrator meter installed in the bottom section of the drum meters feeds pellets onto silage as it is conveyed to cattle. The upper half of the drum serves as a bin.

From the graphs in figure 8, you can determine the metering capacity at various gate openings and coil voltages of a meter constructed as shown in figure 7. At a given coil voltage, meter output will vary in terms of percentage of maximum metering capacity for a particular feed material at different gate openings. For example:

The right-hand graph shows that 540 pounds of soybean meal per hour are metered through a 2½-inch gate opening at 110 coil voltage. Referring to the left-hand graph, you find that with that gate opening, the 540-pounds-per-hour metering rate is 45 percent of maximum capacity.

With coil voltage the same,

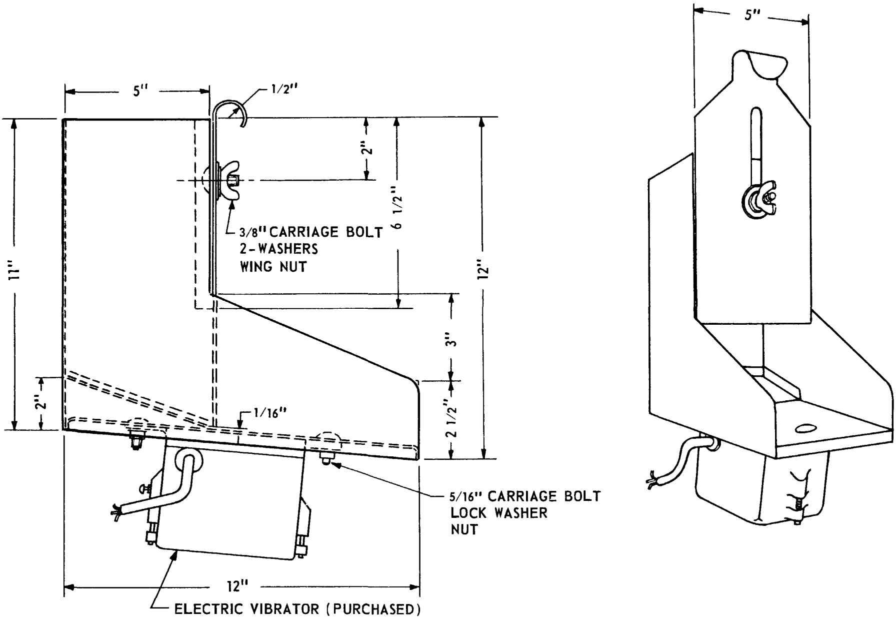

Figure 7.—Construction of the vibrator feed meter.

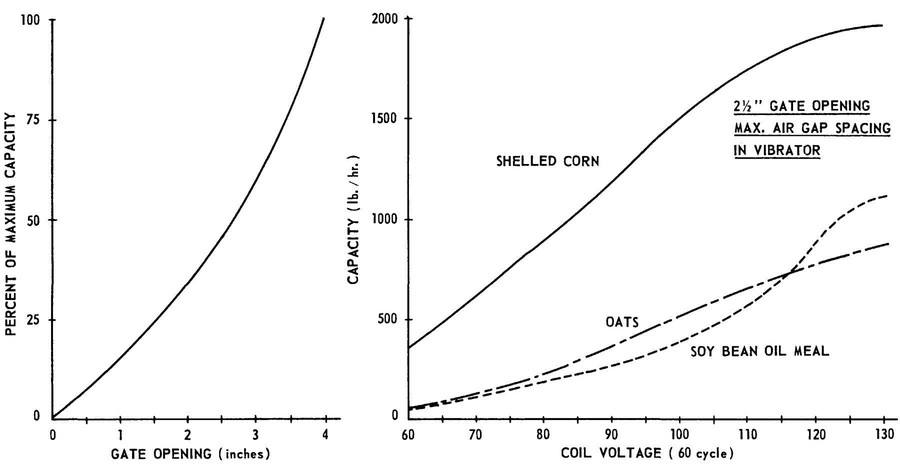

Figure 8.—Typical metering rate curves for the vibrator meter shown in figure 7.

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but gate opening reduced 1 inch, the metering rate drops to 16 percent of maximum capacity (or 192 pounds per hour).

MILL (GRINDER)

Different types of mills are available for processing feed—hammer, burr, crimper, crusher, and roller. Each type comes in different sizes or capacities. The type and size of mill needed will depend on—

- Kind of feed material to be processed.
- Capacity required.
- Finished feed characteristics desired.

In general, hammer mills are best for fine and medium grinding and burr mills for coarse grinding.

In an automatic feeding system, feed should be processed at a low rate over the maximum period of time. Small, low-capacity, electrically operated equipment, which costs less to buy and to operate, can be used and more efficient operation of the equipment obtained.

A small, automatic feed grinder (2 to 3 horsepower) can be used to process small grain and supplement, including shelled corn. It should be automatically controlled. The automatic control system may consist simply of adequate feed meters and an interval timer.

Some cattle feeders and dairymen prefer to feed ground ear corn instead of ground shelled corn, because of the higher roughage content. Automatic grinding of ear corn involves the problems of uniform flow of corn into the mill and smooth operation of mill and motor. Either of two methods may be used:

Precrushing

The corn can be crushed with a crusher-type mill before it is ground. A hoppered bin, sloped on two sides, can feed the corn into the crusher, and an auger meter can meter the material from the crusher and convey it to the mill. Precrushing the corn provides uniform flow of material into the mill and, therefore, smooth operation. But an extra piece of equipment—the crusher mill—is required, and the power requirements per ton of feed ground will be the same as in the overload-control method discussed below.

Overload Control

You can grind ear corn without crushing it beforehand if the mill is equipped with suitable electrical controls to prevent severe overload of the motor. This method requires—

(1) A 5-horsepower, low-inertia hammer mill. (Tests indicate this to be the most practical type and size for automatic ear corn grinding.) The mill must have low inertia so that an increase in load will be reflected very quickly as an increase in motor current.

(2) A current-sensing device in the mill motor circuit that will stop the meters and, therefore, the flow of feed when the motor current reaches a preset level. This can be a magnetic- or electronic-type controller (fig. 9).

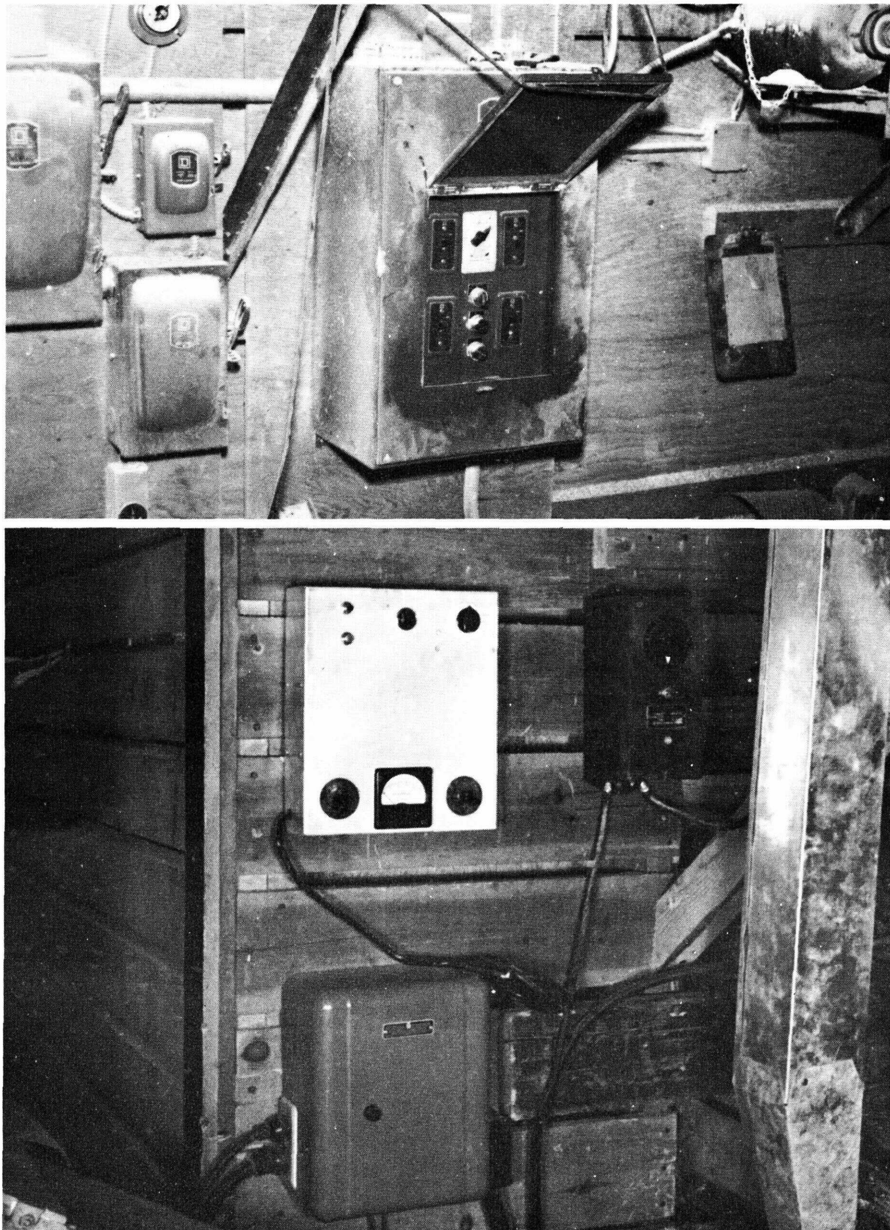

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Figure 9.—A magnetic control for an ear corn grinder (top) uses a current sensitive relay to regulate operation of the feed meters. An electronic control (bottom) uses a current transformer and electronic relay to regulate operation of the meters. The electronic relay is more sensitive than the magnetic current relay.

(3) A feeding mechanism to the mill that can be stopped quickly and in which the flow of feed immediately stops. If feed continues to flow into the mill after the meters shut off, enough may enter to stall the motor. An auger can stop material flow quickly and completely (fig. 10).

(4) A hopper-bottom corn crib and an ear corn crib drag (fig. 11) to remove and meter the corn from the crib into the mill.

CONVEYORS

In an automatic feeding system, the feed moves from storage to processing (mixing and grinding) and then to the feeding points.

Equipment or methods that may be used to move or convey the feed include bucket elevators, augers, and pneumatic conveying systems.

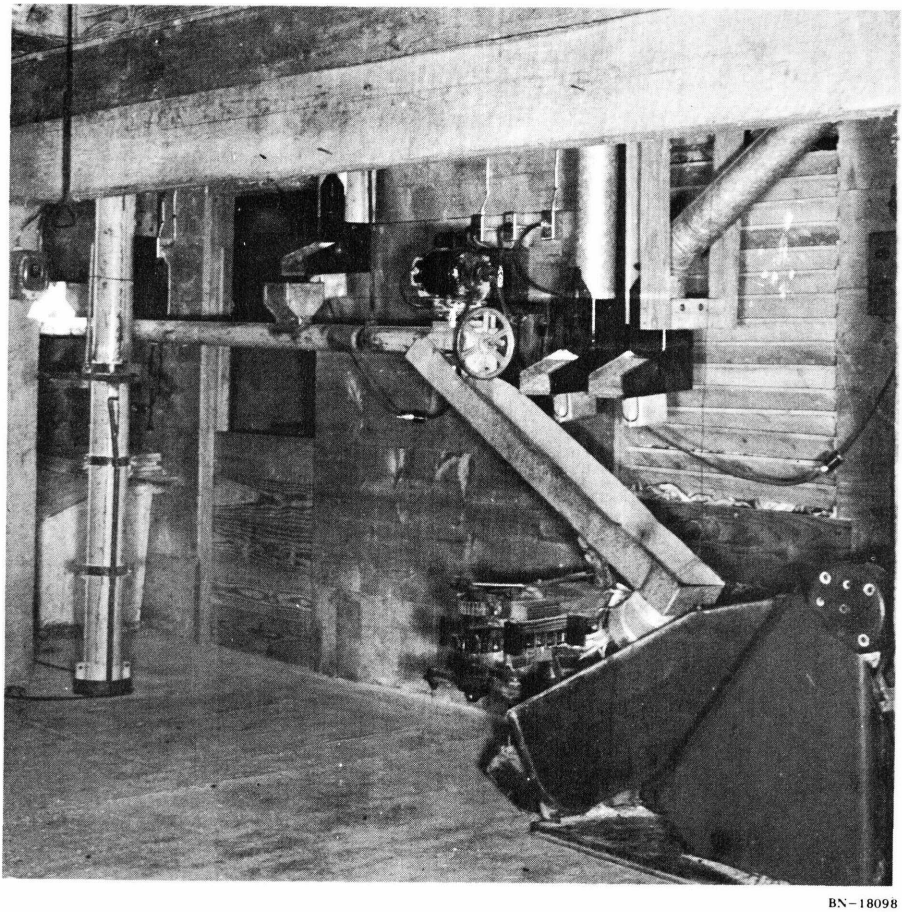

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Figure 10.—An auger can stop the flow of feed into the automatic ear corn mill quickly and completely if the mill motor becomes overloaded.

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Figure 11.—Ear corn can be metered from a hopper-bottom crib with a drag chain.

Bucket Elevators

Bucket elevators are the most efficient method of conveying feed vertically. They handle the feed gently and will not damage whole grain.

This type of conveyor is used primarily where a large amount of material must be elevated and lifted 40 feet or more and for into-storage handling or storage-to-storage transfer.

Augers

Augers are a less efficient method of conveying materials than bucket elevators. Also, they will cause some size reduction in ground-feed particles and will damage seed material if used for vertical conveying. However, in spite of these disadvantages, they are very practical for feed-processing systems, because of their low cost and versatility. They can be used to convey feed from storage to processing and from processing to the feeding points.

Augers are available in various sizes and in different lengths in each size. A number of auger lengths can be connected together to convey feed for several hundred feet.

Conveying capacity and power requirement of augers depend on auger size, length, conveying angle, and operating speed and on the kind of material conveyed.

Following are points to consider in using augers in feed-processing systems:

A single powered auger is generally used to convey feed in a straight line only; gears or flexible shafts would be required to change the direction of conveying. Where a change in the direction of conveying is necessary, a second auger and drive motor will probably be less expensive. A shaftless low-capacity auger, developed commercially, can convey material around long-radius bends. This greatly increases the versatility of the auger conveyor.

Augers are most efficient in conveying capacity and power requirement when conveying horizontally. Capacity decreases and power requirement increases as the conveying angle is increased.

Augers should be operated at the slowest speed that will provide the desired delivery rate. An increase in operating speed

can increase capacity, but also increases the power requirement.

Longer augers require proportionately more power than shorter ones at a given speed and delivery rate. For example, an auger 40 feet long requires twice the power of one 20 feet long.

An auger must have the capacity to handle the quantity of feed delivered to it by the preceding auger or other component of the system. For example, an auger with a maximum conveying capacity of 200 bushels of feed per hour should not receive feed from one conveying 300 bushels per hour.

Pneumatic Conveying

Pneumatic conveying, in which the feed is blown through piping, is an efficient method of conveying ground feed from the storage and mixing area to the feeding points and offers several advantages over mechanical conveying (belts, augers, etc.):

- A pneumatic conveying system is simpler in construction and easier to install and can include turns.
- Initial cost of a pneumatic conveying system will probably be less where conveying distance exceeds 200–300 feet.
- All operating equipment in a pneumatic conveying system is at one location, which facilitates servicing and maintenance.
- The lightweight piping used in pneumatic conveying systems can be suspended overhead or, in the case of one system, buried underground.

Two systems of pneumatic conveying have been tested and used for automatic feed distribution—the high-volume, low-pressure and the low-volume, medium-pressure. The basic difference between the two is the volume of air moved and the air pressure used.

High-Volume, Low-Pressure System.—This system uses an air pressure of less than 2 pounds per square inch, which is supplied by an impeller-type blower (fig. 12). Feed can be satisfactorily conveyed for a distance of approximately 300 feet. The system has several disadvantages: Large size pipe is required and it must be installed with care; the high volume of air moved causes excessive dust at the discharge point; and the feed enters the system through the blower and comes in contact with the blower wheel, which causes size reduction of the feed particles.

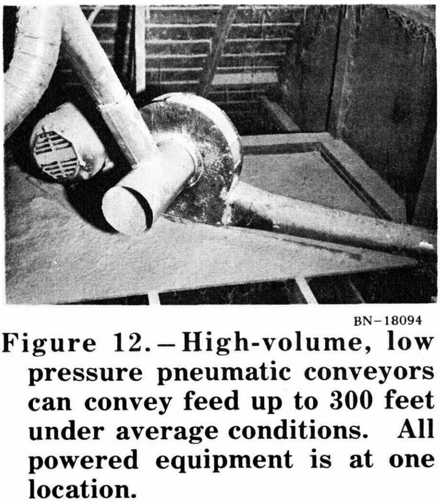

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Figure 12.—High-volume, low pressure pneumatic conveyors can convey feed up to 300 feet under average conditions. All powered equipment is at one location.

Low-Volume, Medium-Pressure System.—This system uses an air pressure of up to 20 pounds per square inch, which is supplied by a rotary-type air pump (commonly known as a "roots" blower) or by a rotary vane-type compressor. This system has these advantages over the high-volume, low-pressure conveyor:

- It is easy to install and control, and feed can be routed from one loading point to any of several discharge points.
- The higher air pressure used and the smaller volume of air moved permit more efficient conveying.
- The smaller volume of air moved causes much less dust at the discharge point.
- Smaller pipe—1 to 4 inches in diameter—is used.

Valving and piping systems developed for commercial pneumatic conveyors of this type can be used for feed distribution on farms.

DISTRIBUTORS

In an automatic feeding system, the ground feed is conveyed from storage bins or the mill to the feeding points. There it must be distributed before the animals.

Methods by which the feed may be distributed before the animals are:

- A self-feeder can be filled automatically by an auger (fig. 13) or by a pneumatic conveyor.
- A conveyor can deliver the feed to an auger mounted above a feed bunk, which will distrib-

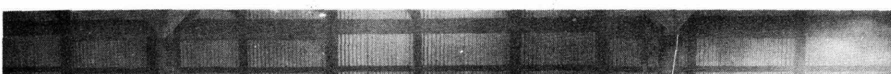

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Figure 13.—An auger can distribute feed to several outlets in succession without adjustment. Here an auger conveyor fills one of several hog feeders.

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Figure 14.—Large diameter augers are an excellent method of distributing feed in a cattle feed bunk.

ute the feed throughout the bunk (fig. 14).

● A conveyor can deliver the feed to a bunk equipped with an endless chain that is pulled through the bottom of the bunk and returned underneath or a shuttle stroke conveyor that pushes the feed in the bunk.

Auger, chain, and shuttle-stroke, conveyors can also be used to distribute silage throughout a feed bunk.

AUTOMATIC CONTROLS

Low-horsepower, low-capacity, electrically powered equipment designed to process feed at a low rate over a maximum period of time is the most practical for feed preparation and distribution systems. And for most efficient and economical operation, the equipment should be automatically controlled and operated.

Relatively simple, inexpensive electric controls are available that can regulate and synchronize operation of the various equipment components in the system so that only minimum supervision or manual control by the operator is required.

The simplest and most useful controls for automatic feed preparation and distribution are the time switch (24-hour repeat cycle timer and interval timer), the time-delay relay, and the pressure switch.

Time Switch

A time switch can regulate both the frequency and duration of the feed-processing operations—that is, the number of operations to occur per day, per week, or per any time base desired and the length of time the system operates each operating period.

Figure 15 shows a 24-hour time switch or clock. It can energize a circuit (turn on a feed-processing system) every hour or any hour of the day for a period of 2 to 55 minutes.

Figure 16 shows an interval timer, which can time individual operations. It is manually set for the desired operating period (10 minutes to 5 hours), and at the end of that time, it turns off the circuit.

Time-Delay Relay

Time-delay relays (fig. 17) can control the operating sequence of equipment in a feed-processing and distribution system. It is often necessary to start and stop several pieces of equipment in a definite order.

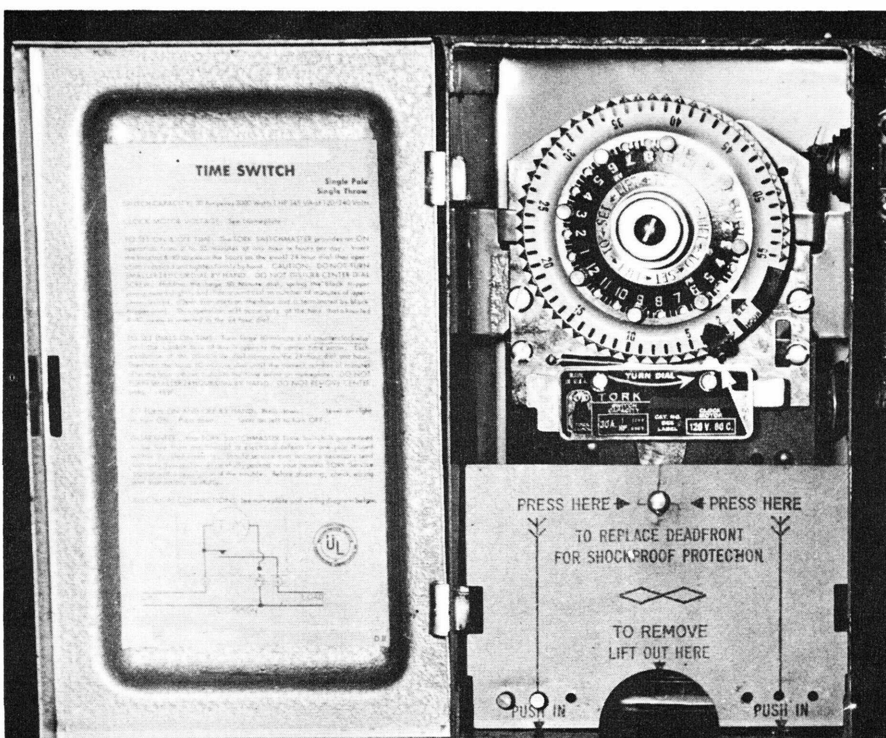

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Figure 15.—Time clocks are very useful controls for automating feeding operations.

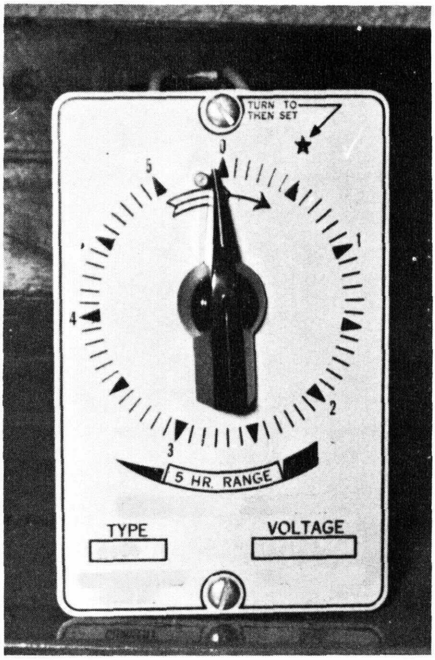

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Figure 16.—Interval timers, electric or spring drive, can time individual operations.

For example: A grinder feeds material into a conveyor. To prevent plugging of equipment, the conveyor must start several seconds before the grinder at the beginning of the feed-processing operation and stop several seconds after the grinder at the end of the operation.

Pressure Switch

A pressure switch (fig. 18) can be used as the primary control or as a safety device in an automatic feeding system. Operation of the switch is simple—the pressure or nonpressure of material on the pressure plate of the switch opens or closes the electric circuit. Installed in a feeder or bin, the switch can start the feed-preparation and conveying system when the feeder or bin is emptied and stop

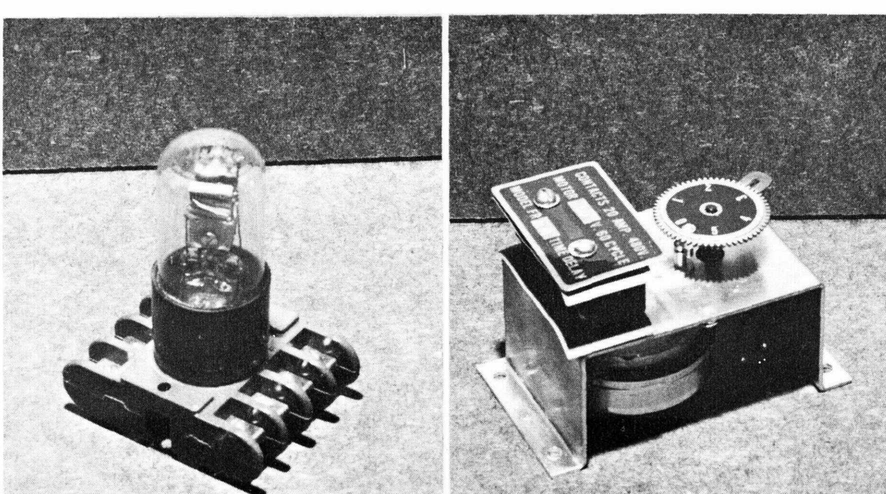

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Figure 17.—Time-delay relays can be used to start and stop equipment in the proper sequence. Left, a thermostatic time-delay relay; right, a synchronous motor-driven relay.

the system when the feeder or bin is full.

Interlocking of electric controls in an automatic feeding system through the proper combination of relays and switches is important to prevent improper operation that could damage the equipment or cause feed to be delivered to the wrong point.

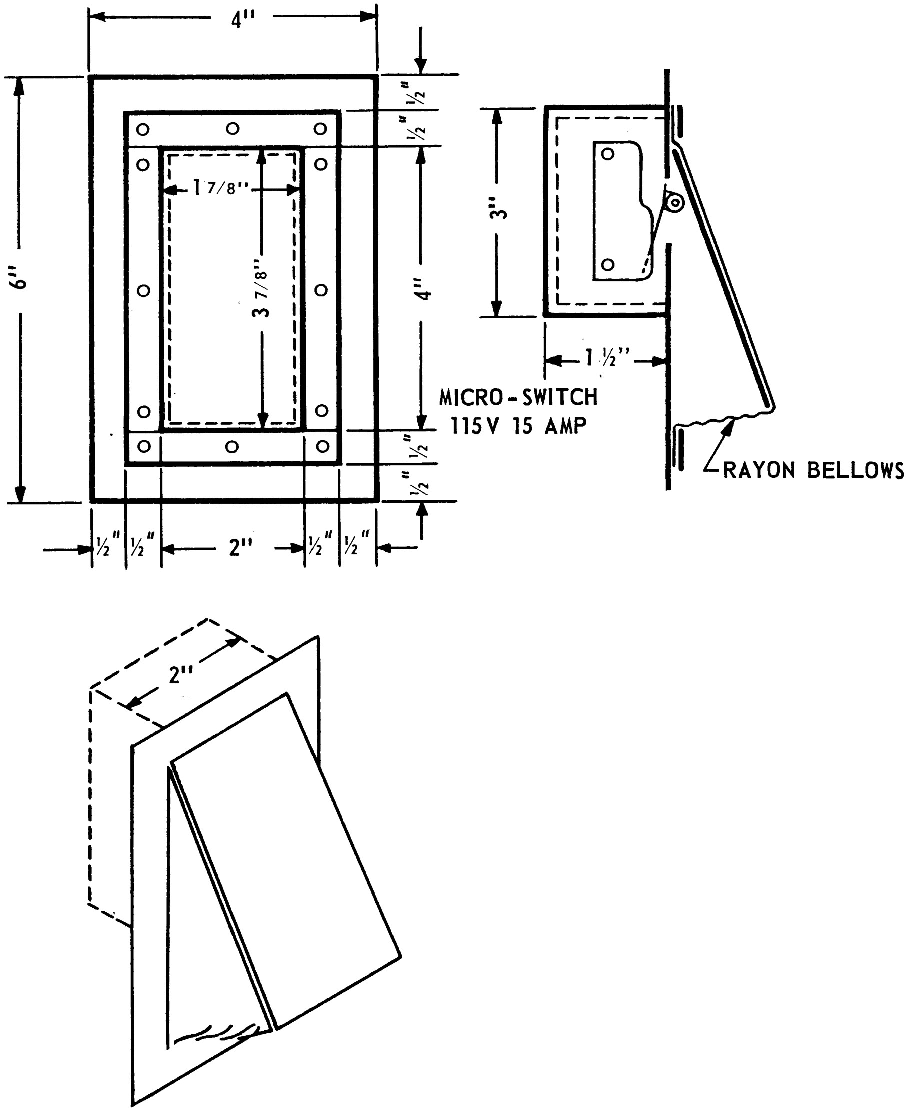

Figure 18—A pressure switch can be used as the primary control or as a safety device in an automatic feeding system.

PLANNING A FEEDING SYSTEM

An automatic feeding system should –

- Reduce feeding costs.
- Save labor and eliminate undesirable tasks.
- Provide a ration of the desired quality and quantity.

No single system can suffice for every livestock or poultry feeding operation. Each system must be installed according to the particular feeding requirements and existing facilities and equipment.

Consult your county agent, power supplier, and equipment dealer for advice and assistance. Some equipment dealers offer complete planning, installation, and maintenance services for automatic feeding systems. Frequently, all equipment required or desired is available from one dealer.

Circumstances may permit installation of only part of the system at a time. But a complete plan should be drawn up initially. Then equipment can be added later with minimum change.

The plan would include information on the type and number of animals to be fed, kind and quantity of feed required, and type and amount of equipment needed to store, process, and convey the feed. It would also include a flow diagram showing location and capacity of existing facilities and equipment and proposed installation of new equipment.

Following are some important points to remember in designing an automatic feeding system:

- Wherever you can mechanize or automate an operation efficiently, do so.
- Move feed as little as possible and over minimum distances.
- Make the flow of feed continuous from storage to feeding points to eliminate unnecessary operations, such as secondary storage.
- Review your initial design for ways to increase efficiency and eliminate unnecessary operations.

EXAMPLES OF FEEDING SYSTEMS

Several examples of operating feeding systems are illustrated in figures 19, 20, and 21. These are typical of the arrangements that have been successfully employed.

Three experimental feeding systems under development are described in the following paragraphs. These systems have been automated to reduce or eliminate the labor required to prepare and distribute feed to livestock. However, the operator must realize that automatic feeding equipment is not a substitute for livestock management and cannot replace the herdsman.

POULTRY FEEDING SYSTEM

This automatic feeding system (fig. 22) *is installed on an Illinois farm. The owner feeds approximately 30,000 turkeys each year.*

Eight different feed ingredients are stored in bulk storage bins.

Automatically controlled augers remove the ingredients from the bins and convey them to an automatic hammer mill with self-contained meters, which mixes and grinds the feed.

The mill discharges the feed into a medium-pressure pneumatic conveying system (32 cubic feet of air per minute at 7-1/4 pounds of air pressure per square inch). Feed enters the conveying system through an airlock, which is similar in principle to a revolving door. An air compressor supplies the air pressure which blows the feed through 1-inch, rigid, metal piping to the feeding points.

The system has two control units—one on the mill and the other on the wall. The power control unit on the mill consists of interlocked relays and safety devices which operate the equipment and prevent damage in case of malfunction. The distribution-control panel, on the wall, contains the controls which regulate distribution of the feed to the feeding points. This unit includes subassembly controls for each feeding point.

The system automatically prepares a feed ration containing up to four ingredients and delivers it to feeding points up to 400 feet from the mill at a rate of 1,200 pounds per hour.

HOG FEEDING SYSTEM

This automatic feeding system (fig. 23) *is part of a complete hog-finishing system, which includes pen cleaning and waste disposal. In design and operation, it is similar to the poultry feeding system described above.*

The feed ingredients are stored in bulk storage bins.

Automatically controlled 4-inch augers remove the ingredients from the bins and convey them to an automatic 2-horsepower hammer mill with a self-contained four-auger blender.

The mill discharges the mixed and ground feed ingredients into a medium-pressure pneumatic conveying system. Feed enters the conveying line through a small feeder valve. A rotary vane-type air compressor supplies the air pressure which blows the feed through the conveying pipe. The pipe is installed underground for convenience.

The pneumatic conveying system discharges the feed into a small hopper on the feeder. An auger removes the feed from the hopper and distributes it in a feed trough.

The system is controlled by interlocked relays, timers, and safety devices. A time clock or a feed-level switch in the feed hopper controls operation of the entire system. Any one of the safety devices on motors and meters can stop the system if trouble develops.

CATTLE FEEDING SYSTEM

This automatic feeding system (fig. 24) *is an experimental unit designed to feed silage in addition to grain and supplement.*

Silage is stored in a concrete stave silo, grain in a self-unloading bin, and protein supplement in a hopper-bottom bin.

An automatically operated mechanical silo unloader—automatically raised and lowered—unloads the silage at a uniform rate. (Operation of the unloader can be adjusted so that the unloader discharges from 50 to 150 pounds of silage per minute.) The silage drops down the silo chute into an auger conveyor.

Augers convey the grain and supplement from the storage bins to a blender-grinder unit. An auger conveys the ground feed from the grinder to a small hopper, where a vibrator meter meters it onto the silage.

The silage-concentrate ration is conveyed to a feed bunk, where a bunk distributor (an auger) distributes it uniformly to either side or to both sides of the bunk.

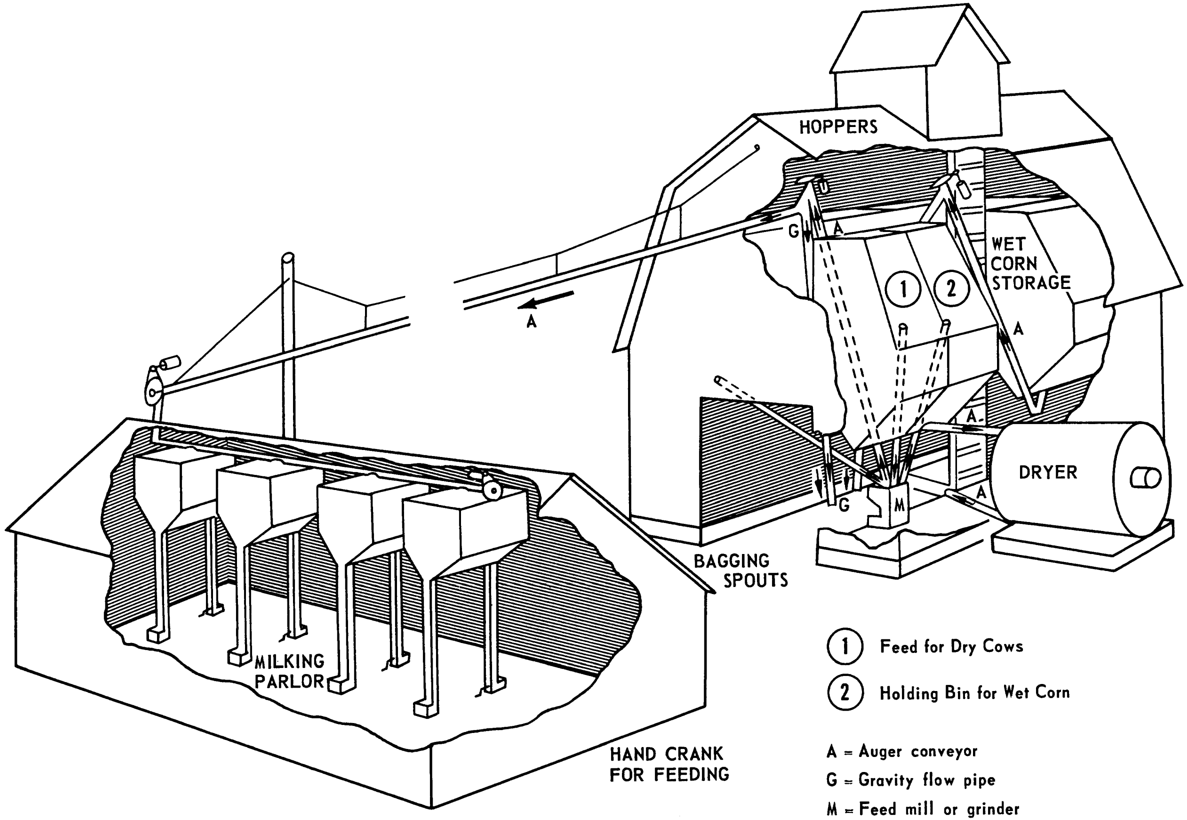

Figure 19.—This feed-handling system provides for automatic corn drying as well as automatic preparation of a dairy ration. Feed is delivered automatically to the milking parlor stalls. 240 cows are fed from this system.

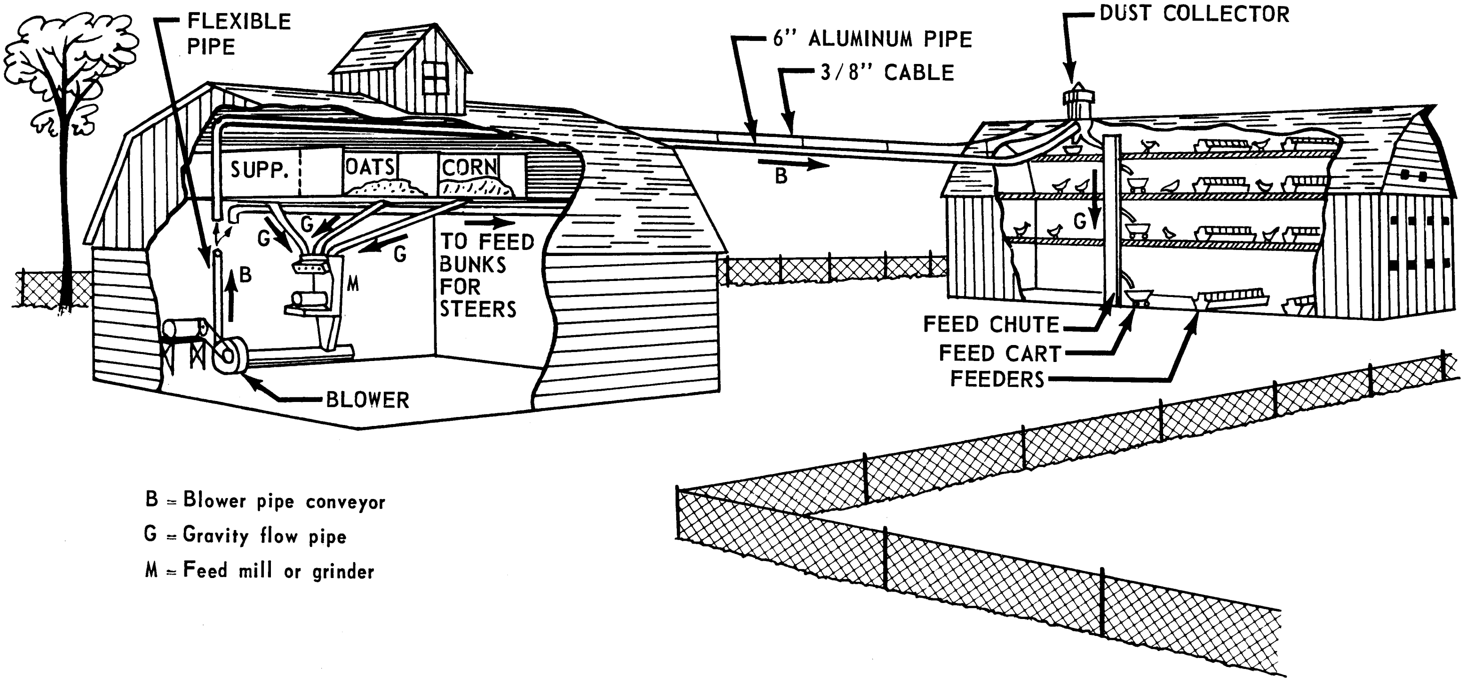

Figure 20.—This system provides automatic feed preparation and delivery by a high-volume, low-pressure pneumatic conveyor for 30,000 broilers and 100 steers.

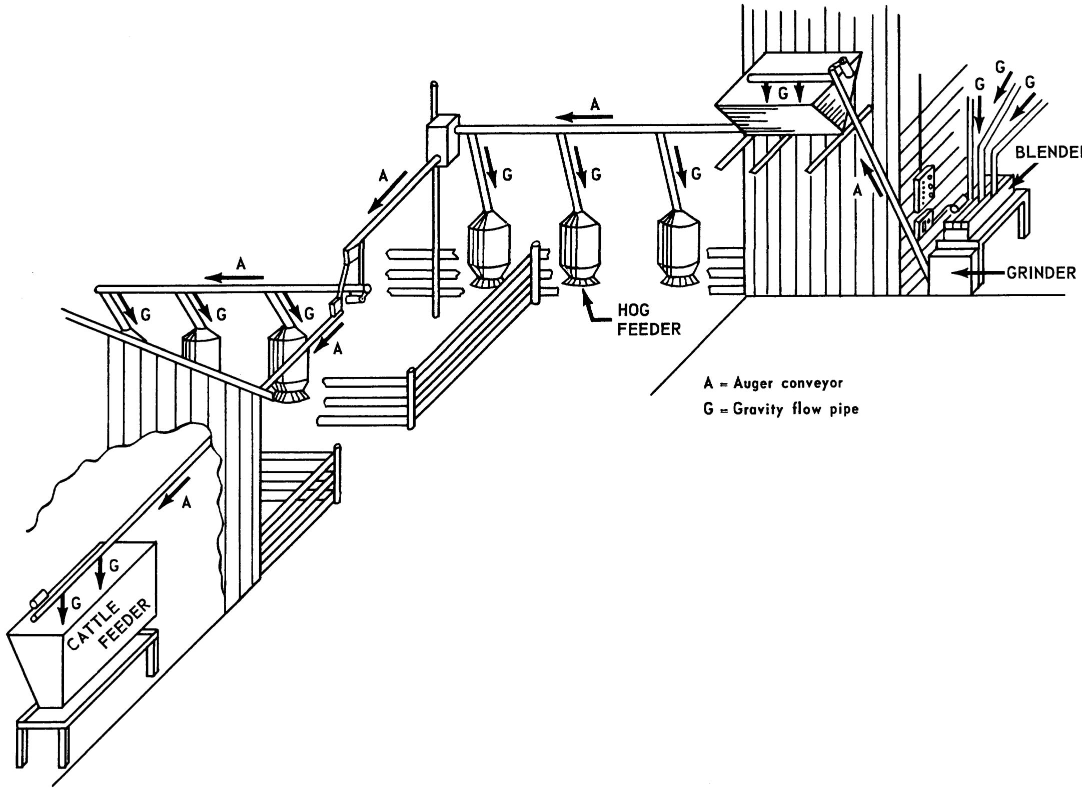

Figure 21.—This system illustrates how several different rations can be prepared and delivered by the same equipment. Note how the conveying augers are connected to change the direction of flow and extend the conveying distance. 150 beef cattle and 500 hogs are fed from this system.

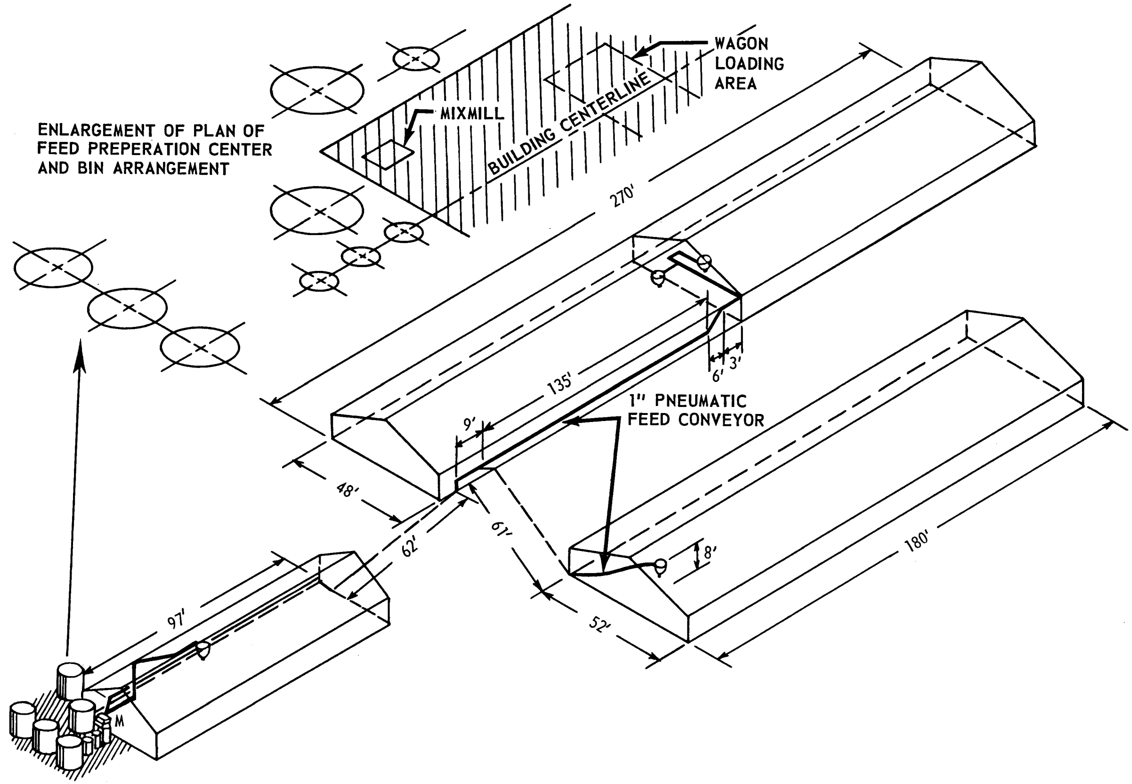

Figure 22.—Poultry feeding system used to prepare and distribute feed for 30,000 turkeys. An experimental low-volume, medium-pressure pneumatic conveyor conveys the feed through 1-inch piping. Electric motors totaling 7 horsepower operate the equipment. This system is operated a maximum of 8 hours per day.

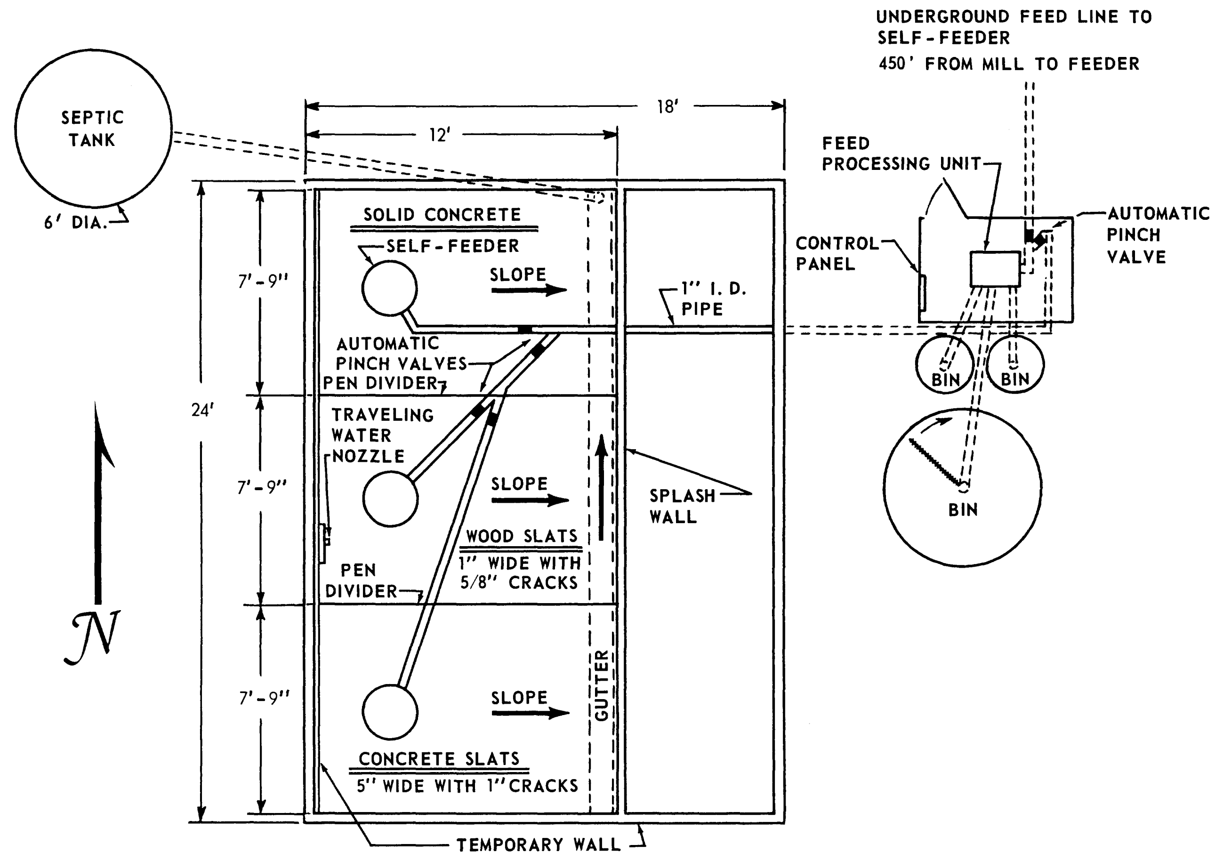

Figure 23.—Hog feeding system (part of a complete hog-finishing operation).

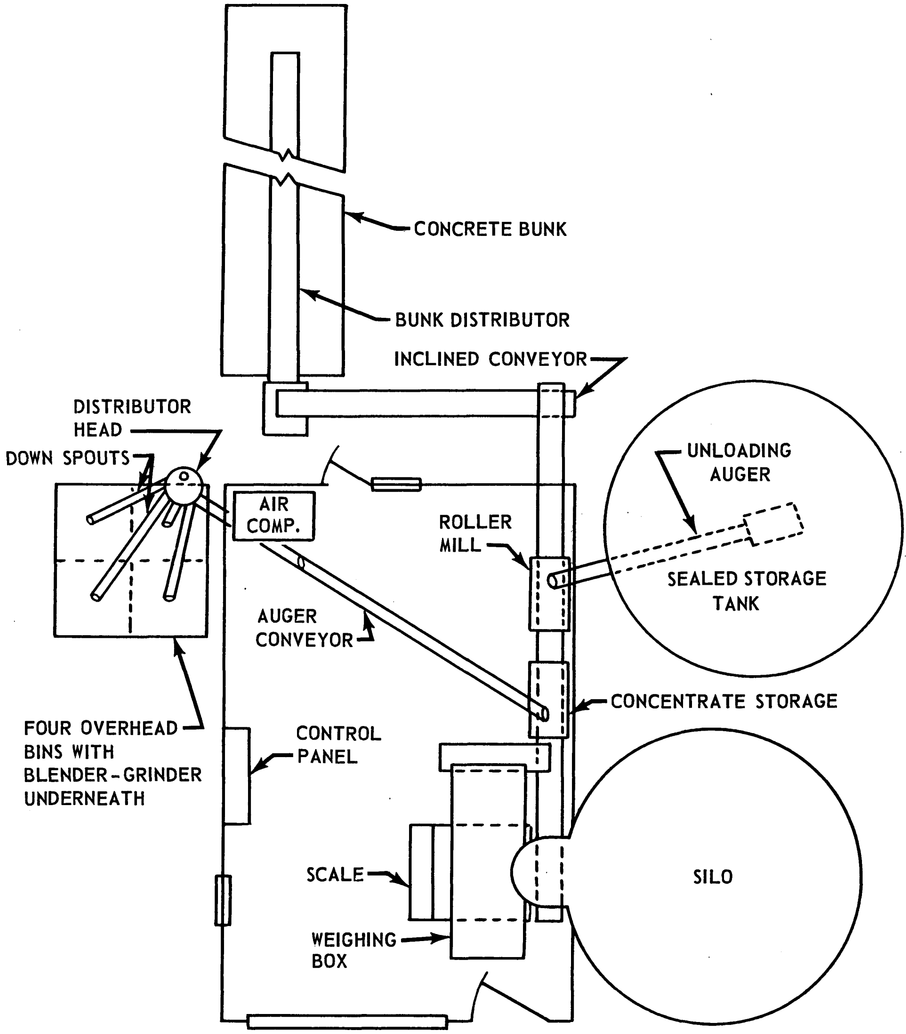

Figure 24.—Cattle feeding system designed to feed silage in addition to grain and supplement.

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